INDOOR AIR QUALITY ASSESSMENT

Manchester-Essex Regional Middle High School
36 Lincoln Street
Manchester, MA 01944

Prepared by:
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Center for Environmental Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Roger Young, Business Manager, Manchester-Essex Regional School District, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health's (CEH) Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at the Manchester Essex Regional Middle High School (MERMHS), 36 Lincoln Street, Manchester-by-the-Sea, Massachusetts. On March 7, 2004, a preliminary visit was made to the MERMHS by Michael Feeney, Director of BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) Program. Mr. Feeney was accompanied by Sharon Lee, Environmental Analyst, ER/IAQ during the assessment. On April 14, 2004, Ms. Lee returned to the MERMHS to conduct a full indoor air quality assessment. Reports of inadequate ventilation and concerns regarding the art area prompted the assessment.

The MERMHS is a brick building with a centralized courtyard. The original one-story building and gymnasium were constructed in 1961. In 1971, the two-story Davis building was constructed. Another wing that connects the Davis building to the gymnasium was built in the mid-1970s, essentially closing the building to create a central courtyard. Other renovations and additions were also made during the 1970s.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). BEHA staff also performed visual inspection of building materials for water damage and/or microbial growth, as well as other sources of respiratory irritants.

Results

The school complex houses approximately 500 seventh through twelfth grade students and over 80 staff members. Tests were taken under normal operating conditions. Results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were elevated above 800 parts per million (ppm) in 5 of 44 areas surveyed, indicating adequate air exchange in most areas. It is important to note that a number of areas were empty or sparsely populated and/or had windows open at the time of the assessment. Low room occupancy and open windows can greatly reduce carbon dioxide levels. Of note was classroom 22, which had carbon dioxide levels above 800 ppm while unoccupied, indicating poor air exchange in this particular room.

Fresh air in most classrooms is supplied by unit ventilators (univent) that were installed during construction of the classrooms (Picture 1). A univent draws air from outdoors through a fresh air intake located on the exterior wall of the building and returns air through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. Obstructions to airflow, such as desks and other items located in front of univents were observed in some areas. Many univents were not operating or were operating weakly at the time of the assessment. To function as designed, univents must remain free of obstructions and be allowed to operate.

Fresh air is mechanically supplied to audio/visual wing rooms, various offices, as well as second floor classrooms and library via ceiling-mounted diffusers ducted to air-handling units (AHUs). The thermostat-controlled system is the primary source of fresh air supply. The thermostat can be set to either "auto" or "on" (Picture 2). In one area, the thermostat was found in the "auto" position, which deactivates the HVAC system once the pre-set temperature on the thermostat is reached (Table 1). As a result, the AHU was deactivated and fresh air circulation was limited. Occupants in the art/pottery room reported that the AHU servicing this room had been deactivated. In order to dilute odors and particulates produced in the art/pottery room area, the AHU must be activated and allowed to operate as designed.

Mechanical exhaust ventilation consists of ceiling-or wall-mounted exhaust vents (Picture 3), which are ducted to rooftop motors. At the time of the assessment, these vents were either off or operating weakly throughout the building. Most classroom exhaust vents are located on walls perpendicular to the hall doorway. When hall doors are open, the exhaust vent is blocked, thereby preventing the draw of classroom air. As with univents, exhaust vents must be allowed to operate and remain free of obstructions.

In addition to mechanical exhaust, classrooms in the middle school and high school math/science wings have passive exhaust vents in hallway walls (Picture 4). The likely function of these vents is to remove odors and/or smoke produced by chemistry/biology experiments. This design allows air to pass through a classroom and into the hallway. An exhaust vent is located in the hallway (Picture 5). The vent is ducted to a motorized rooftop fan and aides draw of classroom air into the hallway. Some hallway exhaust vents appeared to be closed at the time of the assessment.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last servicing and balancing was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that a room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

The temperature measurements ranged from 69^{o} F to 77^{o} F, which were within or very close to the BEHA recommended comfort guidelines (Table 1). The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. Building occupants reported problems with temperature control, especially in second floor classrooms. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Temperature control is often difficult without operating the ventilation systems as designed (e.g., univents/exhaust vents obstructed).

The relative humidity measured ranged from 44 to 63 percent, which was within or slightly above the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. The sensation of dryness and irritation is common in a low relative humidity environment. Relative humidity levels in the building would be expected to drop during the winter months due to heating. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of rooms had water-stained ceiling tiles, which are an indication of leaks originating from the roof, skylight or pipe system (Picture 6 and 7). Water-damaged ceiling tiles can provide a source of mold growth. Water-damaged ceiling tiles should be replaced after a water leak is discovered and repaired. Appropriate measures should be taken to minimize the aerosolization of particulates from tile removal/replacement.

Signs of efflorescence and water intrusion were noted on cement walls in the wood shop area (Picture 8). Efflorescence is a characteristic sign of water damage to building materials such as cement or plaster, but it is not mold growth. As moisture penetrates and works its way through exterior wall, water-soluble compounds dissolve, creating a solution. As the solution moves to the surface of the interior wall, water evaporates, leaving behind white, powdery mineral deposits. This condition indicates that water from the exterior is penetrating the building.

Portions of the MERMHS have windows constructed from ridged-plastic material. Condensation formation was noted in these windows (Picture 9). Upon closer inspection, breaches were noted in the exterior panel of the window (Picture 10) and portions of the window frame were missing (Picture 11). Water penetrating through the window can result in water damage to other building materials (Picture 12). Condensation accumulation between window panels may also result in microbial growth.

In addition, window-mounted air conditioners are installed in some areas. Wood is used to frame air conditioning units in the windows (Picture 13). Seams were noted between the wood frame and unit. Such seams can allow water to penetrate the building.

Plants and shrubs were also growing in close proximity to the MERMHS building (Picture 14). The growth of roots against the exterior walls can bring moisture in contact with wall brick. Plant roots can eventually penetrate the brick, leading to cracks and/or fissures in the foundation below ground level. Over time, this process can undermine the integrity of the building envelope, providing a means of water entry into the building through capillary action through foundation concrete and masonry (Lstiburek & Brennan, 2001).

Plants were noted in several classrooms. In one science room, evidence of an apparatus once used for a plant project remained (Picture 15). Plants can be a source of pollen and mold, which can be respiratory irritants for some individuals. Water-damaged porous materials (e.g., paper) can serve as a source for mold growth (Picture 16). Plants should be properly maintained and equipped with drip pans. Plants should also be located away from univents and other ventilation sources (e.g. openable windows) to prevent aerosolization of dirt, pollen or mold.

Other sources for water damage were also observed. Open seams between the sink countertop and wall were observed in several rooms (Picture 17). If not watertight, water can penetrate through the seam, causing damage. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage.

The American Conference of Governmental Industrial Hygienists (ACGIH) and United States Environmental Protection Agency (US EPA) recommend that moistened materials be dried with fans and heating within 24 to 48 hours of becoming wet (ACGIH, 1989; US EPA, 2001). If porous materials (e.g. carpeting, paper goods) are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to such materials is not recommended.

Other Concerns

Indoor air quality can also be adversely impacted by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion products include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the school environment, BEHA staff obtained measurements for carbon monoxide and PM2.5.

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide pollution and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

ASHRAE has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2000a). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS established by the US EPA, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2000a).

Carbon monoxide should not be present in a typical, indoor environment. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect or ND (Table 1). Carbon monoxide levels measured in the school were also ND.

The US EPA also established NAAQS for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits for particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2000a). This standard was adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA proposed a more protective standard for fine airborne particles. This more stringent, PM2.5 standard requires outdoor air particulate levels be maintained below 65 $\mu g/m^3$ over a

24-hour average (US EPA, 2000a). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, BEHA uses the more protective proposed PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 19 $\mu g/m^3$ (Table 1). PM2.5 levels measured indoors were in a range of 11 to 77 $\mu g/m^3$. The highest measurement of 77 $\mu g/m^3$ was in classroom 9. Classroom 9 is a science classroom. The classroom consists of multiple laboratory benches that are accessible by a centralized walkway spanning the length of the room. Many of these workbenches were crowded with assorted materials (Picture 18). The large amount of items stored in this classroom provides a source for dust to accumulate. In addition, the classroom univent was not operating at the time of assessment, and the wall-mounted exhaust vent was obstructed by boxes, furniture and other items. Operation of the ventilation system would reduce PM2.5 concentration, since the supply system introduces fresh air to dilute the space and the exhaust system removes particulates. Other areas, such as classroom 11 and the lounge area also had higher PM2.5 measurements because of lack of ventilation.

PM2.5 measurements in the wood shop and the pottery area were also elevated above background levels, with measurements of 33 and 37 respectively. In these cases, measurements can be attributed to the use of the spaces without activation of mechanical ventilation system. Woodworking produces wood dust and other debris. Although localized exhaust is connected to wood working equipment, the local exhaust cannot dilute nor completely remove airborne dirt, dust or debris. Similarly, the kiln in the pottery area has a dedicated exhaust. The purpose of a kiln exhaust is to vent products produced during the firing of pottery. Such exhaust ventilation would have minimal effect during mixing or working of clay.

Frequently, indoor air levels of particulates can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system; cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to determine whether VOCs were present in the building, air monitoring for TVOCs was conducted. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND. Indoor TVOC concentrations were ND in all but one area. The darkroom had a TVOC measurement of 0.8 ppm, which may be attributed to developing chemicals. Please note, that the TVOC air measurements are only reflective of the indoor air concentrations present at the time of sampling. Indoor air concentrations can be greatly impacted by the use TVOC containing products.

While no measure able TVOC levels were detected in the indoor environment, VOC-containing materials were noted. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Of concern is the chemical hood in classroom 9 (Picture 19). Standard chemical hood units are constructed of metal sheeting. In contrast, this chemical hood is constructed of laminated particleboard. Over time, the laminate is prone to degradation (e.g. cracking, peeling). These breaches in the laminate allow odors and particles generated from chemicals and hood activities to penetrate the particleboard. Such odors and particles can also collect in the particleboard material. Use of ventilation hood exhaust can reduce odors and material accumulation. Even with adequate ventilation, odors, vapors and particles can still penetrate the particleboard.

On the day of the April 14, 2004 assessment, BEHA staff observed materials stored in the chemical hood (Picture 20). The exhaust ventilation for the unit was not operating at the time. Exhaust ventilation for chemical hoods should be operational at all times to ensure vapors and odors off gassing from materials placed within chemical hoods are removed. Stock bottles and other chemical materials were also noted on laboratory benches (Picture 21). Chemicals should be returned to chemical storage areas once experiments have been completed.

Several other conditions that can affect indoor air quality were noted during the assessment. Missing ceiling tiles and breaches, such as a pipe extending though the ceiling tile system, were noted in many areas. Open pipes, breaches, and missing ceiling tiles can serve as pathways for dust, dirt, odors and other pollutants to move into occupied areas. A number of exhaust/return vents were noted with accumulated dust. If exhaust vents are not functioning, back drafting can occur, which can re-aerosolize accumulated dust particles.

As discussed, the amount of materials stored inside classrooms, especially in classroom 9, is noteworthy. In classrooms throughout the school, items were seen on windowsills, tabletops, counters, bookcases and desks. The amount of items stored in classrooms provides a means for dusts, dirt and other potential respiratory irritants to accumulate and make it difficult for custodial staff to clean.

The floor and walls of the pottery side of the art room were coated with clay dust and residue (Picture 22). The most notable layers were located on and around pottery wheels (Picture 23). Clays contain silicates which can become easily aerosolized and serve as eye and respiratory irritants. The Center for Occupation Hazards, located in New York City, recommends avoiding all procedures that create dust (COH, 1979). Several measures to avoid the accumulation of clay dusts include wet mopping and wet wiping of horizontal surfaces (sweeping and dusting can stir up fine particulates) and use of a vacuum cleaner equipped with a high efficiency particulate arrestance (HEPA) filter to reduce the aerosolization of respirable dusts. Consideration should also be made towards purchasing wet clay that does not require mixing. If clay must be mixed, wear proper National Institute for Occupational Safety and Health (NIOSH) approved respiratory protection and/or conduct mixing under local exhaust ventilation or in a chemical hood (usually located in science areas).

Accumulated chalk dust was noted in some classrooms. Chalk dust is a fine particulate that can easily become aerosolized. Once aerosolized, chalk dust can become irritating to eyes and the respiratory system. Similarly, pencil shavings were observed to be accumulating at the base of pencil sharpeners. When windows are opened, pencil shavings can become airborne, providing a source of eye and respiratory irritation.

Currently, the kiln is fitted with an exhaust that removes exhausted materials outdoors (Picture 24). The exhaust vent is located on the exterior wall of the MERMHS (Picture 25). Above the kiln exhaust vent appears to be a disabled exhaust vent for a previously existing exhaust system. The previous system is still intact within the classroom (Picture 26). Under certain weather and wind conditions, materials exhausted from the functioning kiln exhaust may be forced into the deactivated exhaust system. As a result, materials removed from the kiln may penetrate into the pottery area and subsequently become aerosolized. To prevent distribution of kiln materials, the deactivated vent should be sealed.

Lastly, during a perimeter inspection of the building, BEHA staff observed signs bird roosting and nesting materials in an exhaust fan on the exterior of the building (Picture 27). Birds can be a source of disease, and bird wastes and feathers can contain mold and mildew, which can be irritating to the respiratory system. No obvious signs of bird roosting inside the building were noted by BEHA staff nor were such signs reported by occupants. This nest should be removed to prevent entrainment of bird wastes. The purpose and function of the exhaust fan should be determined/assessed. If possible, consider sealing the exhaust fan to prevent bird roosting.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Examine each univent for function. Operate univents while classrooms are occupied. Check fresh air intakes for repair and increase the percentage of fresh air intake if necessary.
2. Examine exhaust vents for function and make repairs as necessary.
3. Operate all ventilation systems that are operable throughout the building (e.g., gym, auditorium, classrooms) continuously during periods of school occupancy independent of thermostat control to maximize air exchange.
4. Remove all obstructions from univents and exhaust vents to facilitate airflow. Remove leaves from subterranean exhaust vent pits.
5. Consult a ventilation engineer concerning re-balancing of the ventilation systems and the calibration of univent fresh air control dampers throughout the school. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).
6. Identify and repair sources of water leaks (e.g., window frames and roof). Replace water-damaged ceiling tiles. Examine non-porous surfaces beneath ceiling tiles and disinfect with an appropriate antimicrobial.
7. Examine plants in classrooms for mold growth in water catch basins. Disinfect water catch basins if necessary.
8. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

9. Reduce clay dust accumulation by wet mopping and wet wiping horizontal surfaces. Use a vacuum cleaner equipped with a high efficiency particulate arrestance (HEPA) filter to reduce the aerosolization of respirable dusts.
10. Consider discontinuing use of the laminate particleboard based chemical hood.
11. Consider adopting the US EPA (2000b) document, Tools for Schools, in order to provide self-assessment and maintain a good indoor air quality environment at your building. The document can be downloaded from the Internet: http://www.epa.gov/iaq/schools/index.html.
12. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. Copies of these materials are located on the MDPH's website: http://www.state.ma.us/dph/beha/iaq/iaqhoFtme.htm.

Long Term Recommendations

1. Consider purchasing a standard metal-based chemical hood, equipped with localized exhaust.
2. Consider purchasing wet clay that does not require mixing. If clay must be mixed, wear proper NIOSH approved respiratory protection and/or conduct mixing under local exhaust ventilation or in a chemical hood (usually located in science areas).
3. Consider replacing window panels.

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Picture 1

Classroom univent

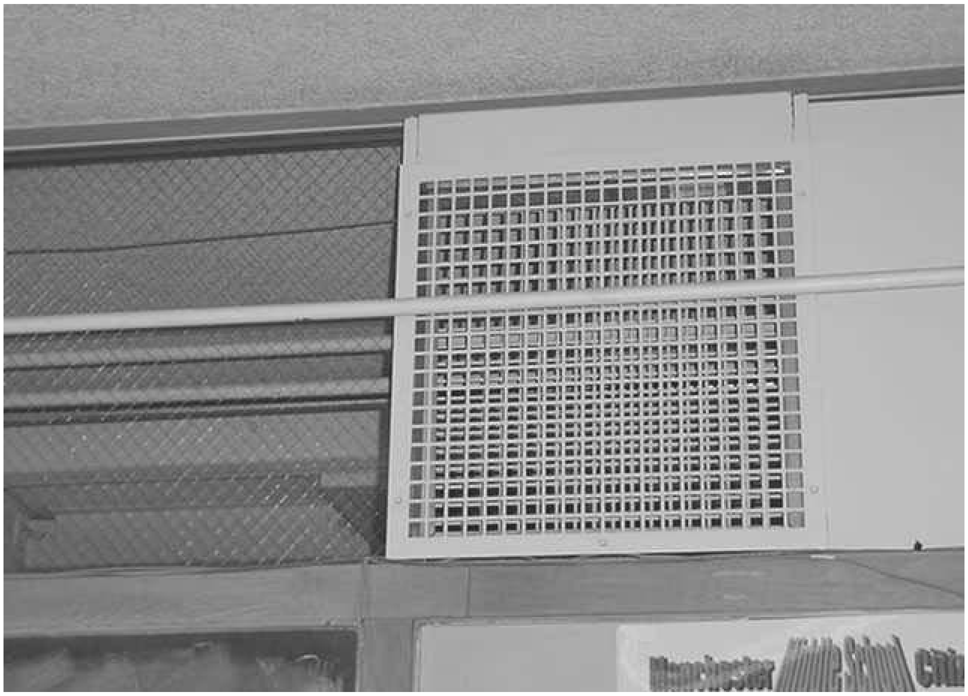
Picture 2

HVAC control unit set to 'auto"

Picture 3

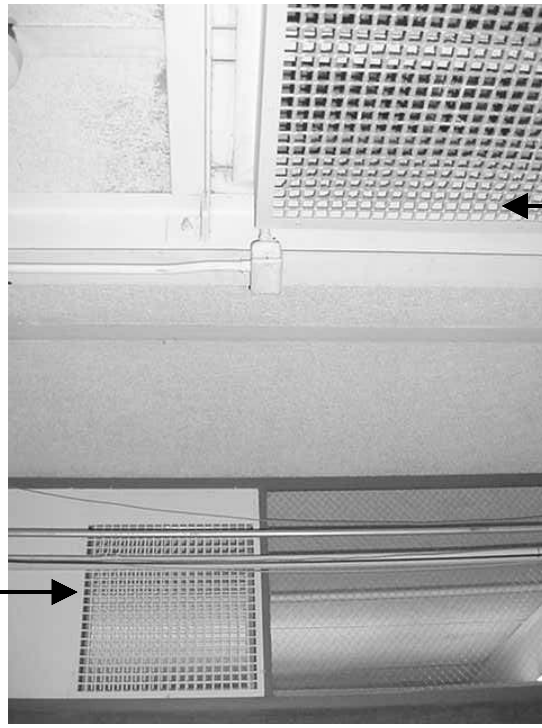
Mechanical classroom exhaust vent, note location and proximity to door

Picture 4



Passive classroom exhaust vent

Picture 5



Location of classroom vent to hallway vent

Picture 6

Water-damaged ceiling tile (new wing)

Picture 7

Water-damaged ceiling tile (old wing)

Picture 8

Efflorescence and signs of water instrusion

Picture 9

Condensation between window panes

Picture 10

Breach in window pane

Picture 11

Missing portion to window frame

Picture 12

Stained exterior wall material

Picture 13

Seam between wood frame and window-mounted air conditioning unit

Picture 14

Shrubbery growing in close proximity to building

Picture 15

Decomposing plant material

Picture 16

Plant placed on paper materials

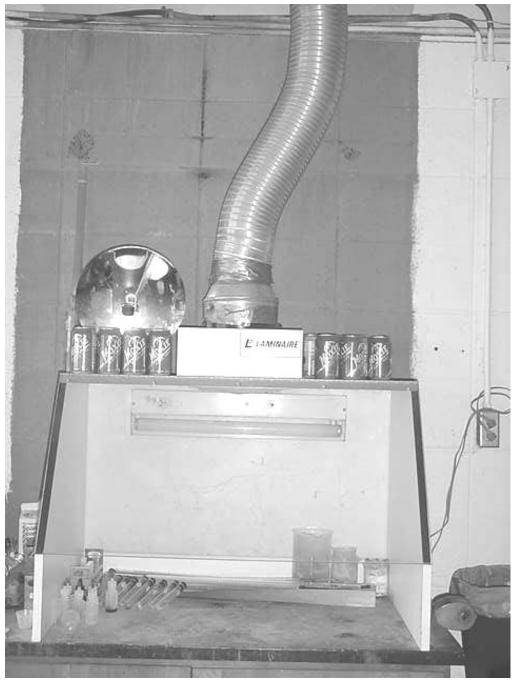
Picture 17

Breaches between countertop and backsplash

Picture 18

Acummulated materials placed on lab workbenches

Picture 20



Chemical hood in Classroom 9 (March 10)

Picture 21

Chemical storage in hood

Picture 22

Chemical storage on lab work benches

Picture 23

Clay dust on room fixtures

Picture 24

Clay dust and materials around pottery wheel

Picture 25

Disabled kiln exhaust

Kiln with attached exhaust, note previous exhaust system

Picture 26

Exhaust vent on exterior wall, note exhaust from previous system

Picture 27

Previous kiln exhaust system, note openned hatches

Picture 28

Birds’ nest in exhaust fan

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
background	ND	57	57	319	ND	ND	19	N # open: 0 # total: 0			overcast, light rain.
9C	11	70	63	742	ND	ND	30	Y # open: 1 # total: 6	Y wall	N	Hallway door open, FC re-use, food use/storage, plants.
17	14	72	56	647	ND	ND	26	Y # open: 3 # total: 6	Y univent (weak)	Y wall (off)	Hallway door open, clutter, plant(s), #WD-CT : 3, CD, clutter, FC re-use, plants, Comments: passive wall exhaust.
16	22	75	50	825	ND	ND	24	Y # open: 1 # total: 4	Y univent (weak)	Y wall	clutter, #WD-CT : 1, CD, DEM.
9S	ND	72	51	470	ND	ND	27	Y # open: 4 # total: 4	Y univent (weak)	Y wall	Hallway door open, clutter, #WD-CT: 4, DEM, PF, Comments: stored paints.
15	ND	77	45	631	ND	ND	25	Y # open: 0 # total: 4	Y univent (off)	Y wall (off)	Hallway door open, CD, cleaners, Comments: passive wall exhaust.
10	11	75	47	630	ND	ND	25	Y # open: 2 # total: 4	Y univent (off)	Y wall	Clutter, CD, clutter, Comments: passive wall exhaust.

ppm = parts per million
µg/m3 = micrograms per cubic meter

AD = air deodorizer
AP = air purifier
aqua. = aquarium

AT = ajar ceiling tile
BD = backdraft
CD = chalk dust
CP = ceiling plaster
CT = ceiling tile
DEM = dry erase materials

design = proximity to door
FC = food container
G = gravity
GW = gypsum wallboard
M = mechanical
MT = missing ceiling tile

NC = non-carpeted
ND = non detect
PC = photocopier
PF = personal fan
plug-in = plug-in air freshener
PS = pencil shavings

sci. chem. = science chemicals
TB = tennis balls
terra. = terrarium
UF = upholstered furniture
WD = water damage
WP = wall plaster

Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
11	23	73	51	685	ND	ND	41	Y # open: 4 # total: 4	Y univent (off)	Y wall	Hallway door open, clutter, vent location, WD-other, #MT/AT : 2, CD, DEM, PF, cleaners, Comments : passive wall exhaust; WD paper under plant; pipe breaching from CT.
14	23	73	51	681	ND	ND	32	Y # open: 4 # total: 4	Y univent	Y wall	Hallway door open, furniture, CD, Comments: passive wall exhaust.
12	1	74	48	578	ND	ND	24	Y # open: 2 # total: 4	Y univent	Y wall	Hallway door open, DEM, Comments: passive wall exhaust.
13	17	76	47	802	ND	ND	30	N # open: 0 # total: 0	Y univent (off)	Y wall (off)	#WD-CT: 4, CD, food use/storage, Comments : univent set to on, but was off.
lounge	1	73	48	785	ND	ND	57	Y # open: 0 # total: 3		Y ceiling (off)	Hallway door open, window-mounted AC, DEM.
gym	ND	73	49	478	ND	ND	25	N # open: 0 # total: 0	Y wall	Y wall (off)	Comments: broken window.
girls locker room	ND	69	53	401	ND	ND	26	N # open: 0 # total: 0		Y ceiling wall	

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Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
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Manchester Essex Regional Middle High School **Indoor Air Results**

36 Lincoln Street, Manchester, MA 01944 **April 14, 2004**

Table 1

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	PM2.5 (µg/m3)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
boys' locker room	ND	69	53	399	ND	ND	26	N # open: 0 # total: 0		Y ceiling wall	
23/24	ND	71	51	536	ND	ND	24	Y # open: 2 # total: 4	Y univent (off)	Y ceiling	Hallway door open, #MT/AT : 1, DEM, clutter.
22	1	73	52	1013	ND	ND	32	Y # open: 0 # total: 1	Y univent (off)	Y ceiling (off)	Hallway door open, CD, clutter.
9	20	76	48	919	ND	0.4	77	Y # open: 1 # total: 6	Y (off)	Y wall	Clutter, boxes, furniture
5	13	76	44	609	ND	ND	21	Y # open: 2 # total: 2	Y univent (off)	Y wall	CD, DEM, Comments: passive exhaust vent; 22 computers.
7	2	75	44	625	ND	ND	21	Y # open: 2 # total: 6	Y univent (off)	Y wall	Hallway door open, #WD-CT: 6, CD, cleaners, plants, Comments : passive wall exhaust.
4	ND	74	44	510	ND	ND	24	Y # open: 4 # total: 4	Y univent (off)	Y wall (off)	Hallway door open, vent location, CD, Comments: passive wall exhaust.
3	1	75	45	548	ND	ND	20	Y # open: 0 # total: 4	Y univent (off)	Y wall	Hallway door open, vent location, CD, Comments: passive wall exhaust.

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guidance - main	3	74	46	657	ND	ND	21	N # open: 0 # total: 0	Y wall	N	
guidance director	ND	71	47	515	ND	ND	22	Y # open: 1 # total: 1	N	N	Inter-room door open, window-mounted AC,
guidance - conference	2	73	47	655	ND	ND	20	Y # open: 0 # total: 3	Y wall (off)	N	Inter-room door open, window-mounted AC, PF.
middle school counselor	ND	74	44	625	ND	ND	19	N # open: 0 # total: 0	Y wall (off)	N	Inter-room door open, PF.
high school counselor	1	74	45	670	ND	ND	19	Y # open: 0 # total: 1	Y wall	N	Inter-room door open, Comments: AHU set to 'auto'.
kitchen	3	71	50	537	ND	ND	24	Y # open: 2 # total: 2	Y univent		Exterior door open, Inter-room door open, Comments: reports of heat and gas odors; poor stove exhaust function.
19 (tech drafting)	1	73	47	480	1	ND	27	N # open: 0 # total: 0	Y univent (off)		Hallway door open, Inter-room door open, window-mounted AC, CD, PF, Comments : 20 computers.
wood shop	12	69	51	466	ND	ND	33	N # open: 0 # total: 0	Y univent (off)	Y wall	Exterior door open, Inter-room door open, WD-other, Comments: efflorescence on wall; 6 CT replaced with wood; paint odors.

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									Supply	Exhaust	
music room	5	70	51	481	ND	ND	15	N # open: 0 # total: 0	Y ceiling	Y wall	Hallway door open,
art/drawing	5	70	55	502	ND	ND	26	Y # open: 0 # total: 3	Y ceiling (off)	Y wall	Hallway door open, #MT/AT : 16, Comments: painted CT; area HVAc reportedly off.
art/pottery	2	71	55	486	ND	ND	37	Y # open: 2 # total: 2	Y ceiling (off)	Y wall (weak)	Hallway door open, kiln, breach sink/counter, #MT/AT : 3, clutter, Comments : pottery dust; glazer.
dark room	ND	71	56	497	ND	0.8	16	N # open: 0 # total: 0			
126	17	71	57	691	ND	ND	21	Y # open: 2 # total: 0	Y ceiling	Y wall	CD, DEM.
editting room	6	71	55	646	ND	ND	18	N # open: 0 # total: 0	Y ceiling	Y ceiling	Hallway door open, food use/storage.
125	9	70	55	545	ND	ND	20	Y # open: 2 # total: 4	Y ceiling	Y wall	CD, DEM, clutter.
Athletics' office	2	72	54	569	ND	ND	19	N # open: 0 # total: 0		Y wall	Hallway door open,

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library	5	71	53	515	ND	ND	17	N # open: 0 # total: 0	Y ceiling	Y wall	breach sink/counter, CD, plants.
234	24	70	55	583	ND	ND	14	Y # open: 1 # total: 4	Y ceiling	Y wall	Hallway door open, Inter-room door open, #MT/AT : 1, CD, DEM, clutter.
233	1	70	53	468	ND	ND	11	Y # open: 8 # total: 8	Y ceiling	Y ceiling wall	Hallway door open, DEM, PF, plants, temperature complaints (cold), temperature complaints (hot).
232	25	71	55	585	ND	ND	12	Y # open: 1 # total: 6	Y ceiling	Y wall	Hallway door open, Inter-room door open, DEM, plants, Comments : DEM odors.
8	ND	73	53	486	ND	ND	13	Y # open: 2 # total: 4	Y univent (off)	Y wall (off)	Hallway door open, food use/storage.
1	25	73	48	684	ND	ND	17	Y # open: 2 # total: 4	Y univent (off)	Y wall (off)	Hallway door open,

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